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NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE

Folwell Avenue, St. Paul, Minnesota 55101

Characteristics of Blister Rust Cankers on Eastern White Pine

ABSTRACT. — The growth, development, and sporulation of white pine blister rust cankers were studied on eastern white pine in Wisconsin and Minnesota. Three distinct canker types were identified on the basis of physical appearance, growth rate, and sporulation. Canker growth rate and sporulation decreased as tree size or age increased, and many cankers apparently became inactive. High mortality of branch cankers was associated with older trees, heavily stocked stands, and small branch diameter.

OXFORD: 172.8 *Cronartium ribicola:* **174.7** *Pinus strobus:* **(775) (776)**

The physical appearance, growth, and sporulation of white pine blister rust (*Cronartium ribicola* Fischer) cankers on eastern white pine (*Pinus strobus* L.) were studied from 1962 to 1967 in the high hazard blister rust zone of northern Wisconsin and Minnesota. These cankers exhibited substantial natural variation in both appearance and growth characteristics. Information on natural variation is of value not only because of general biological interest but also because it may aid in future evaluation of chemical treatments. It is now known that many cankers do not fit the standard "textbook" description. Failure to recognize this variation in canker appearance led to misinterpretation of results in some early tests, in which antibiotics were concluded to have controlled white pine blister rust.

METHODS

The study trees ranged in age from 8 to 31 years and in size from 2 to 10 inches d.b.h. They were all untreated control trees from other experiments conducted to evaluate the effectiveness of chemicals for white pine blister rust control. All trees had at least one apparently active bole canker that girdled less than 60 percent of the stem. Most bole cankers originated when the trees were seedlings or saplings, and 94 percent were less than 8 feet above the ground. The physical appearance of more than 15,000 cankers was recorded prior to chemical treatment. In addition, growth of 400 bole cankers and 81 branch cankers was measured annually over the 5-year period on control trees that were not treated with chemicals.

RESULTS AND DISCUSSION

Examination of blister rust cankers on eastern white pine showed the presence of three distinct types of bole cankers. The typical, or "textbook," canker is confined almost entirely to young trees and the smooth-barked portion of older trees. This is a relatively young canker with a yellow-green or orange-green margin that is usually rather puffy in appearance (this marginal color is enhanced by wetting and scrubbing the bark). Such cankers usually produce spores and grow the fastest. With increasing age of both host and canker, there is a gradual change in appearance, growth, and sporulation pattern. Margin coloration usually disappears entirely as the bark roughens on older wood. Canker growth slows down, particularly in the vertical direction, and portions of the canker margin apparently become inactive. Ridges of callus may develop along the lateral margins of the canker. As a result, tree mortality rate decreases with age and in some instances tree diameter growth may exceed the rate of girdling. Sporulation decreases as the canker and tree get older.

The second type, which made up 10 percent of all cankers observed, has no marginal coloration on smooth-barked trees, even when the canker and the tree are young. These cankers, which do not sporulate, develop on both branches and bole; a distinct margin is evident between the brown, necrotic face of the canker and the surrounding live, green bark. Their growth on the bole is usually more rapid laterally than vertically.

The third type of canker, confined primarily to pole-size and larger trees, has a callus ridge on both sides of the entry branch from which blister rust invaded the bole. The canker thus has the appearance of a deep, narrow groove in the bole, extending several inches to several feet in length. A small necrotic

area is found around the entry branch and in most instances no other symptoms are visible— externally, these cankers appear to be naturally arrested. They have no marginal coloration and do not sporulate. Occasionally, canker activity develops beyond the callus ridge and normal blister rust symptoms (i.e., color and sporulation) appear on the opposite side of the bole. About 5 percent of all cankers observed were of this type.

The last two types of cankers are probably more abundant than these percentages indicate because the sample trees on which the percentages are based were selected to meet certain requirements for the chemical tests and are not representative of the genral population of infected trees.

Canker Growth

Bole cankers.— As tree size or age increased, average canker growth rate decreased, and many cankers apparently became inactive (table 1). Growth rate varied greatly among individual cankers within a diameter class and even in the same canker from year to year. Average canker growth was also greater on trees in the most northerly plot locations. As was pointed out earlier in the paper, most of the cankers included in this study were well-established infections. It should be recognized that the decreased canker growth rate with increased tree age is due at least in part to the nature of the sample trees — many older trees with fast-growing infections would have been more than 60 percent girdled, thus excluding them from the sample.

Table 1. — *Growth of blister rust bole cankers*[1]

D.b.h. class (inches)	Average d.b.h.[2]	5-year tree mortality	Cankers	Bole cankers		
				Average annual increase		Natural canker inactivation[3]
				Length	Girdling	
	Inches	Percent	Number	Inches	Percent	Percent
1.0- 4.0	2.9	26	123	4.2	12.6	1
4.1- 6.0	5.0	19	107	3.6	10.0	2
6.1- 8.0	6.9	4	144	2.9	6.8	6
8.1-10.0	8.5	0	26	2.8	6.6	9

[1] Distance from a central point on the canker to the vertical and lateral margins was measured to determine growth rate.
[2] At start of observation period.
[3] No apparent sign of life.

Branch cankers. — Fatal bole infections usually develop from branch cankers. Only 9 percent of the branch cankers on 9- to 13-year-old trees died during the 5-year study period, but a much higher percentage died on 25- to 35-year-old trees due primarily to death of infected branches from shading (table 2). In the 25- to 35-year-old plantations, approximately 45 percent of the branch cankers died in relatively open stands and 70 percent in heavily stocked stands. Stocking level, therefore, is important in determining the amount of fatal bole infection that subsquently develops. Branch diameter, as well as degree of shading, was found to be related to canker mortality. Mortality varied from about 30 percent on branches over 1.6 inches in diameter to 70 percent on branches under 0.5 inch in diameter.

Table 2. — *Analysis of branch cankers during a 5-year period*

SEEDLINGS 8-13 YEARS OLD

Branch diameter class (inches)	Branch cankers	Average annual growth toward the bole	Cankers alive but still in branch at end of 5 years	Cankers that entered bole during 5 years	Cankers dead at end of 5 years
	Number	Inches	Percent	Percent	Percent
0-1.0	13	3.1	29	62	9
POLES 25-35 YEARS OLD					
0-0.5	28	1.9	16	14	70
0.6-1.0	29	2.3	4	40	56
1.1-1.6	17	2.3	5	39	56
1.7+	7	2.1	12	58	30

Canker Sporulation

Production of aecia by bole cankers varied with tree age, locality, and year. On nearly all plots bole canker sporulation and aecial production decreased with increasing tree and canker age. The Minnesota test area showed a consistently lower percentage of cankers producing aecia. This was probably due to parasitism of the rust by the fungus *Tuberculina maxima* Sacc., because this was the only test area where it was present to any extent.

The young, vigorous cankers began aecial production in early May, while the older cankers on rough-bark trees began as late as mid-June and did not produce aecia at all in most years. Aecial pustules were numerous on young cankers and sparse on older ones. Occasionally pustules were produced under rough bark that were not visible on the surface.

Pycniospores were produced over several months, starting about the first of June and continuing into September and October. A much higher percentage of cankers produced pycnia than aecia, and sporulation extended over a greater portion of the canker margins. On some cankers the portions producing pycnia were outlined with map pins, and in many cases these areas did not produce aecia in following years.

WILLIAM R. PHELPS
Plant Pathologist (now with Southeastern Area, State and Private Forestry, Atlanta, Ga.)
RAY WEBER
Forestry Research Technician (retired)